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COMPETITION PERCEPTIONS AND INNOVATION ACTIVITIES: AN EMPIRICAL STUDY OF CANADIAN MANUFACTURING FIRMS

By Jianmin Tang, Industry Canada

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TABLE OF CONTENTS

ABSTRACT v

1. INTRODUCTION 1

2. DATA 5
   - Technology Invention and Technology Adoption 5
   - Competition Perceptions 7
   - Government Supports 9

3. EMPIRICAL ANALYSIS 13
   - Regression Model 13
   - Empirical Results 14

4. CONCLUSION 23

NOTES 25

BIBLIOGRAPHY 29

INDUSTRY CANADA RESEARCH PUBLICATIONS 31

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ABSTRACT

For any given competitive environment, firms will have different perceptions about the degree of competition they are facing. This paper argues that the differences are important if firms are to undertake innovation activities. It uses the Statistics Canada 1999 Survey of Innovation to show that different types of competition perceptions tend to have different effects on technology invention and technology adoption, and some types even have a negative effect on innovation activities. This paper shows that the perception of *easy substitution of products* is an impediment to innovation activities, especially technology invention. In addition, it shows that the perceptions of *constant arrival of competing products* and *rapid change of production technologies* are driving forces behind firms' innovation activities, with the former more important for technology invention and the latter for technology adoption.

1. INTRODUCTION

Innovation is about turning knowledge into economic activity. It is a continuous process of discovery, learning and application of new technologies and techniques from many sources. Today, the greatest gains go to firms that add value through innovation. In fact, during the second half of the 1990s, the phenomenal economic performance of the United States, the world's economic leader, was due largely to its superior innovation record (Council of Economic Advisers, 2001). In the global economy today, a firm has to be highly innovative in order to gain a competitive advantage.

Many policy makers and researchers believe that competition increases the pressure for firms to innovate. "This belief has widespread consequences. It is the driving force behind numerous important policy changes, ranging from the deregulation of numerous sectors in the OECD economies to many of the economic reforms in Eastern Europe" (Nickell, 1996). The theoretical support for this belief is mixed, however. Schumpeter and his associates argue that monopoly power enables firms to spend more on innovation activities. According to Kamien and Schwartz (1982), a firm that possesses monopoly power is likely better able to finance innovation activities and use its power to search for persistent dominance in its market than a firm without monopoly power. A monopoly is more capable of internal financing because of supranormal profits from its monopoly power. Internal financing of an innovation project may be desirable. It may be cheaper than external financing, because of asymmetric information. It may also be particularly important for innovation, especially for technology invention, in terms of protecting the secrecy of a project from competitors.

Many theoretical studies in addition to Nickell argue for a positive relationship between competition and innovation (Dasgupta and Stiglitz, 1980; Porter, 1990; Van de Klundert and Smulders, 1997; Boone and Van Dijk, 1998). "Vigorous global competition against the best-practice companies not only spurs allocative efficiency, it can also force structural change in industries and encourage the adoption of more efficient product and process designs" (Baily and Gersbach, 1995). The argument for a positive relationship between competition and innovation is often based on two main observations. First, with competition, the performance of firms in the same market can be compared. Comparable performance helps investors reward "high-performing" firms and punish "low-performing" firms by providing financial capital at a relatively low cost to the former while withdrawing it from the latter, increasing the pressure for firms to do better than their counterparts. Second, competition raises demand elasticity for the product of competing firms. Increased demand elasticity will generate large gains for a firm if it is successful in obtaining better products or more efficient production processes than its competitors, thereby creating incentives for the firm to innovate. In addition, increased demand elasticity increases the probability of bankruptcy. To avoid it, firms are forced to improve their efficiency. In sum, "it is unclear on theoretical grounds whether greater monopoly power would stimulate innovation in a particular industry and, instead, [it] is an empirical question" (Carlton and Perloff, 2000).

On the empirical front, the evidence on the relationship between innovation and competition is also mixed. For instance, studies testing the Schumpeterian hypothesis find mixed evidence on the relationship between monopoly power and research and development (R&D) spending (as surveyed by Kamien and Schwartz, and Cohen and Levin, 1989). Other studies on the link between competition and general innovation also paint a mixed picture. For instance, Geroski (1990), using data on major innovations introduced in the United Kingdom during the 1970s, finds fairly strong evidence against the hypothesis that increases in competitive rivalry decrease innovation. However, Blundell, Griffith and van Reenen (1999), using a panel of data on British manufacturing firms, find a positive relationship between market share and innovation, measured by headcounts of innovations and patents.

The objective of this paper is to study the relationship between competition and innovation activities empirically, through the use of the *Statistics Canada 1999 Survey of Innovation* (SI). The SI was conducted in 1999 and targetted firms in Canadian manufacturing and selected natural resource industries. It had a response rate of 95 percent, which is probably one of the best response rates to an innovation survey in the world. A detailed description of the SI will be given in the next section.

Unlike most previous studies that use market share or other measures based on industrial statistics to measure competition (e.g., Geroski; Green and Mayes 1991; Nickell; Pilat 1996; Blundel et al.), this paper uses data on firms' perceptions of their competitive environment. This is a significant departure from the literature in three ways. First, for a given competitive environment, different firms may have different perceptions about the degree of competition they are facing. The differences in perception are important, as they lead to different innovation efforts, which partly explain why some firms undertake more innovation activities than others in the same product market for a given competitive environment. Second, the perception-based measure captures firm-specific competition. Firms, even in the same industry, may produce different products or compete in different product markets and thus face different degrees of competition. Importantly, only the firm itself has first-hand information in this regard. In contrast, market share or other competition measures, when they are based on industrial statistics, can be misleading, as firms belonging to the same industry classification group are not necessarily competing against each other.[1] Finally, the perception-based measure reflects not only competition from domestic markets but also competition from overseas markets. Foreign competition is important, especially for Canadian manufacturing firms: 60 percent of their markets are foreign.[2] In contrast, when market share (or another measure) is based on national industry statistics, at most, it captures competition from domestic markets. In order to capture foreign competition, market share has to be calculated in a global environment, and take into account industry statistics in all major markets where a firm is competing. This is a daunting, if not impossible, task.

In addition, firms face various types of competition. The SI data allow us to measure different types of competition and examine their effects on a firm's innovation activities, which usually cannot be addressed through the use of measures based on industrial statistics. This paper explores five types of competition: 1) *easy substitution of products;* 2) *constant arrival of competing products;* 3) *quick obsolescence of products;* 4) *rapid change of production technologies;* and 5) *rapid change of office technologies.* Although there is no clear-cut line between them, the first three types of competition are about product, and the last two are about process. In particular, *easy substitution of products* is product competition that arises when clients can substitute a firm's product for that of its competitors easily. One possible reason for this situation is the ineffectiveness of market framework laws in the area of intellectual property policy.[3] *Constant arrival of competing products* is about general product market competition among same or very similar products. *Quick obsolescence of products* is about competition between old and new technologies (e.g., VCR versus DVD). As for the last two types of competition, *rapid change of production technologies* is about competition in production or manufacturing processes, while *rapid change of office technologies* is associated more with competition in management technologies, such as inventory or human resource management software. These five types of competition will be discussed further in the next section.

Most previous empirical studies, when examining the relationship between competition and innovation, focus on either a broad innovation indicator, such as R&D, or a partial innovation indicator, such as patents. For instance, when testing the Schumpeterian hypothesis, they look at only R&D, an intermediary to technology invention or adoption (as reviewed by Kamien and Schwartz and Cohen and Levin). Similarly, Geroski examines the competition effect on innovations introduced by different industries in the United Kingdom. These studies make no attempt to distinguish one innovation from another. In contrast, this paper explores the rich information in the SI to study the impact of competition

on several different types of technological *innovation activities*.[4] If innovation is designated to mean the state of introducing new or significantly improved products or production processes,[5] then an *innovation activity* is not necessarily innovation, because it may or may not result in innovation. In particular, this paper investigates whether different types of competition will have different effects on technology invention and technology adoption.[6] It uses the term "technology invention" to represent innovation activities associated with pure, in-house invention, and "technology adoption" to represent innovation activities associated with adoption of "off the shelf" technology. Generally, technology invention has more to do with developing or improving products, and technology adoption has more to do with improving production processes or office management. The data do not allow one to accurately measure and differentiate between these two types of innovation activities. as they often form a continuum. For instance, technology invention is often facilitated by new technologies. Nonetheless, this paper uses patent applications as a proxy for technology invention and acquisition of technologies as a proxy for technology adoption.

These five types of competition perceptions tend to have different impacts on technology invention and technology adoption. First, the perception of *easy substitution of products* is found to have a negative and significant impact on innovation activities, especially technology invention. Second, the perception of *constant arrival of competing products* is found to be a positive and significant factor underlying a firm's innovation activities, especially for technology invention. Third, the perception of *quick obsolescence of products* is found to be positive, but only marginally significant, for technology invention. Fourth, the perception of *rapid change of production technologies* is found to be positive and significant for innovation activities, especially for technology adoption. And, finally, the perception of *rapid change of office technologies* is found to be positive and significant for technology adoption and only marginally significant for technology invention.

In the next section, we describe the Statistics Canada 1999 SI and the rationale for selecting variables to link competition perceptions to innovation activities. We also provide descriptive results of those selected variables. In the third section, we set up a regression model for estimating the effects of competition perceptions on the probability of a firm undertaking an innovation activity and then discuss the econometric results under different sample restrictions. We end with concluding remarks in the fourth section.

2. DATA

The data used in this paper are from the Statistics Canada 1999 SI, which focusses on Canadian manufacturing and selected natural resource industries. The sample unit is provincial enterprise. A provincial enterprise is one where all the establishments are in the same province and the industry is at the 4-digit North American Industry Classification System (NAICS) level. For example, if an enterprise has operations with the same 4-digit NAICS level in three provinces, it will be divided into three provincial enterprises. For convenience, a provincial enterprise will be referred to, hereafter, as a "firm." To reduce response burdens, the SI surveyed firms with at least $250,000 gross business income and more than 19 employees in 1999. It surveyed firms for information on their innovation and related activities (including their competitive environment) during the 1997-99 period.[7]

The SI is linked to production data from the 1997 Annual Survey of Manufacturers (ASM). The linked SI contains additional information on firms' operational activities, such as employment in 1997.[8] Employment information is used to divide firms into three groups of different sizes, which will be discussed later in this paper. The linked SI data base contains data on 5,455 manufacturing firms. Each in-sample firm carries a population weight. This allows each in-sample firm to represent other similar non-sampled firms in the population. If the weight given to an in-sample firm is five, then it represents five firms in the population. The 5,455 in-sample firms represent a total population of 8,921 manufacturing firms. For the purpose of this study, however, we exclude four firms without employment information. Thus, the final sample for the analysis in this paper contains data on 5,451 in-sample firms, representing a subpopulation of 8,916 manufacturing firms.

Technology Invention and Technology Adoption

From the linked SI, we select six main innovation activity indicators that are associated with technology invention or technology adoption. They are[9]

1. patent applications;[10]
2. acquisition of technologies;
3. trademarks;
4. copyrights;
5. R&D;[11] and
6. industrial design.

All six are binary ordinal variables. If a firm made patent applications during the 1997-99 period, the indicator for patent applications equals one; otherwise, it equals zero. If a firm used trademarks (copyrights) to protect its intellectual property during the 1997-99 period, the indicator for trademarks (copyrights) equals one; otherwise, it equals zero. Similarly, if a firm engaged in acquisition of technologies during the 1997-99 period, the acquisition of technologies variable equals one; otherwise, it equals zero. This is true for R&D and industrial design as well.

As mentioned earlier, a firm can either invent or adopt, or both invent and adopt. Sometimes, it is necessary to adopt new technologies in order to invent. Thus, in practice, it is difficult to untangle technology invention from technology adoption. Nonetheless, in this paper, we simply use patent applications as a measure of some technology invention activity and acquisition of technologies as a measure of technology adoption. To supplement the two indicators, we also examine trademarks.

copyrights, R&D and industrial design. One could argue that not all inventions are patented. Sometimes it is more desirable to use trademarks or copyrights to protect intellectual property. We therefore analyse trademarks and copyrights, although it is clear that activities associated with them are generally less technological than those associated with patents. We examine R&D and industrial design, as they are both intermediaries to technology invention and technology adoption. The data show that R&D is highly correlated with acquisition of technologies,[12] and industrial design significantly correlated with acquisition of technologies and R&D (Table 1). R&D is certainly necessary for technology invention, but it is also required for technology adoption, as a firm has to engage in R&D activities to absorb and integrate an acquired technology into its overall business operation. Industrial design covers procedures and technical preparations for technology invention or technology adoption, and it may be important, as the right design is necessary for an innovation activity to be successful.

Table 1
Correlation Coefficients between Innovation Indicators

Innovation Activity Indicators	Patent Applications	Acquisition of Technologies	R&D	Industrial Design	Trademarks	Copyrights
Patent Applications	1.00					
Acquisition of Technologies	0.13	1.00				
R&D	0.25	0.39	1.00			
Industrial Design	0.20	0.43	0.46	1.00		
Trademarks	0.28	0.10	0.21	0.12	1.00	
Copyrights	0.23	0.07	0.13	0.09	0.35	1.00

Source: The linked SI

In Table 2, we report the weighted percentage of firms with patent applications, acquisition of technologies, R&D, industrial design, and trademarks or copyrights use to protect their intellectual properties. For the manufacturing sector as a whole, acquisition of technologies is much more popular than patent applications. Although acquisition of technologies is very common in all industries, it is more common in the printing, textile product, and plastics and rubber industries. For patent applications, there is a clear pattern across industries. Among the 21 manufacturing industries, firms in the computer and electronics, electrical equipment, and machinery industries use patents more often than other firms. Firms in the beverage and tobacco, textile product and chemical industries use trademarks more often, and firms in the computer and electronics and beverage and tobacco industries use copyrights more often. Finally, the computer and electronics, electrical equipment, and plastics and rubber industries have the highest percentage of firms engaging in R&D; the electrical equipment, machinery and primary metal industries have the highest percentage of firms undertaking industrial design.

Table 2
Percentage of Firms Engaged in Innovation Activities*
(Weighted by Population)

NAICS	Industry Name	Patent Applications	Acquisition of Technologies	R&D	Industrial Design	Trademarks	Copyrights
311	Food	8.6	**75.8**	**68.9**	54.0	**51.7**	11.9
312	Beverage and Tobacco	18.3	69.2	64.3	54.4	**66.4**	**26.0**
313	Textile Mills	13.2	77.4	**77.0**	**58.3**	30.6	**13.5**
314	Textile Product	**21.7**	79.7	**67.4**	41.5	**59.3**	**15.4**
315	Apparel	3.1	65.6	48.2	32.0	**52.4**	6.3
316	Leather	15.4	70.8	**76.8**	43.5	**55.0**	6.1
321	Wood	5.4	73.6	51.2	51.8	17.5	2.6
322	Paper	17.2	77.6	63.3	**59.0**	27.0	7.1
323	Printing	9.1	**84.1**	51.8	32.4	22.4	**15.6**
324	Petroleum and Coal	**22.2**	68.5	64.8	**57.4**	**42.6**	11.1
325	Chemical	**27.6**	72.4	**77.4**	**57.0**	**55.4**	**17.5**
326	Plastics and Rubber	**28.2**	79.7	**78.8**	**68.3**	**40.4**	11.8
327	Non-metallic Mineral	17.7	57.8	55.9	41.3	29.6	9.7
331	Primary Metal	15.3	**78.9**	**69.5**	**69.8**	18.6	9.0
332	Fabricated Metal	16.6	69.0	57.0	52.9	25.2	7.8
333	Machinery	**35.8**	74.7	**78.1**	**70.3**	**38.1**	**14.0**
334	Computer and Electronics	**38.2**	**79.0**	**83.9**	**69.1**	**47.6**	**30.1**
335	Electrical Equipment	**38.1**	73.4	**79.8**	**71.3**	**39.5**	**16.0**
336	Transportation Equipment	**23.6**	73.5	**68.4**	**66.1**	25.2	**14.9**
337	Furniture	**17.8**	**76.3**	61.5	53.4	35.7	9.1
339	Miscellaneous Manufacturing	**24.9**	73.5	63.7	54.0	**41.2**	**21.5**
	Total Manufacturing	19.0	73.8	65.0	55.0	36.0	12.0

Note: *Above-average numbers are in boldface.
Source: The linked SI.

Competition Perceptions

For competition, we identify five main indicators that are associated with a firm's perceptions on its competitive environment. As noted in the introduction, they are[13]

1. *easy substitution of products;*
2. *constant arrival of competing products;*[14]
3. *quick obsolescence of products;*
4. *rapid change of production technologies;* and
5. *rapid change of office technologies.*

Firms were asked to evaluate their competitive environment by indicating their perceptions on each statement on a scale from 0 to 5, where 0 stands for irrelevant, 1 for strongly disagree and 5 for strongly agree. Clearly, these are firm perceptions on their business competitive environment, and are not restricted to national boundaries. As argued in the introduction, a perception-based measure for competition may be more desirable than a traditional measure based on industrial statistics. For a given competitive environment, different firms may have different perceptions on the degree of competition

they are facing. The differences in perception may explain why some firms undertake more innovation activities than others in the same product market for a given competitive environment. In addition, they capture firm-specific competition, because firms, even in the same industry, may produce different products or compete in different product markets and thus face different degrees of competition. Furthermore, they reflect competition not only from domestic markets but also from overseas markets.

As noted earlier, these five indicators are associated with different types of competition, although there is no clear-cut line between them. The first three are about product competition, and the last two are about process competition. But each of them has a different focus, which to some extent is indicated by the small correlation coefficients between the indicators (Table 3). *Easy substitution of products* is product competition associated with clients. It arises when a firm's clients can substitute its products for the products of its competitors easily. It may concern the same or different but substitutable products and is likely influenced by the effectiveness of the intellectual properties system. *Constant arrival of competing products* is about general product market competition among the same or very similar products. *Quick obsolescence of products* is about competition among old and new technologies, as the obsolescence of products implies the arrival of new and better products. *Rapid change of production technologies* is about competition in production or manufacturing processes, while *rapid change of office technologies* is associated more with competition in management technologies such as inventory or human resource management software.

Table 3
Correlation Coefficients between Competition Perception Indicators

Competition Perception Indicators	Easy Substitution of Products	Constant Arrival of Competing Products	Quick Obsolescence of Products	Rapid Change of Production Technologies	Rapid Change of Office Technologies
Easy Substitution of Products	1.00				
Constant Arrival of Competing Products	0.23	1.00			
Quick Obsolescence of Products	0.04	0.18	1.00		
Rapid Change of Production Technologies	0.00	0.17	0.19	1.00	
Rapid Change of Office Technologies	0.08	0.16	0.11	0.38	1.00

Source: The linked SI.

In Table 4, we report the percentage of firms that strongly agree (a score of 4 or 5) with a statement about their competitive environment. For the manufacturing sector as a whole, the statement with the highest percentage of firms that strongly agree is *rapid change of office technologies*, followed by *easy substitution of products* and *constant arrival of competing products*. However, there is a large variation across industries in these perceptions. Among the 21 manufacturing industries, beverage and tobacco, and paper have the highest percentage of firms that strongly agree with the statement on the *easy substitution of products*; leather, and beverage and tobacco have the highest percentage for *constant arrival of competing products*; apparel, and computer and electronics have the highest percentage for *quick obsolescence of products*; printing and leather have the highest percentage for *rapid change of production technologies*; and leather, and beverage and tobacco have the highest percentage for *rapid change of office technologies*. Clearly, the most intense competition is perceived by firms in resource-based industries such as paper, leather, and beverage and tobacco, although firms in the computer and electronics industry have a strong perception, or awareness, of the quick obsolescence of their products.

Table 4
Percentage of Firms That Strongly Agree*
with Statements About Their Competitive Environment**
(Weighted by Population)

NAICS	Industry Name	Easy Substitution of Products	Constant Arrival of Competing Products	Quick Obsolescence of Products	Rapid Change of Production Technologies	Rapid Change of Office Technologies
311	Food	**63.5**	**60.3**	16.5	**39.9**	62.5
312	Beverage and Tobacco	**75.5**	**65.8**	11.3	39.0	**72.7**
313	Textile Mills	**65.0**	**63.5**	**15.3**	**39.9**	**63.3**
314	Textile Product	59.6	59.1	**13.3**	30.8	**66.5**
315	Apparel	52.2	**62.8**	**26.9**	34.0	59.5
316	Leather	53.2	**69.0**	**18.6**	**50.2**	**74.0**
321	Wood	**64.1**	**54.8**	8.9	**43.6**	**68.0**
322	Paper	**73.5**	49.9	8.3	33.2	**65.4**
323	Printing	**64.5**	53.0	**20.1**	**66.5**	**65.1**
324	Petroleum and Coal	**70.4**	50.0	**16.7**	21.3	**64.8**
325	Chemical	**60.5**	**53.2**	8.8	36.1	**68.7**
326	Plastics and Rubber	55.9	**56.8**	10.1	**39.4**	**65.1**
327	Non-metallic Mineral	**65.0**	49.5	7.0	30.2	**64.2**
331	Primary Metal	**62.1**	**53.1**	4.7	27.7	**69.4**
332	Fabricated Metal	56.8	43.7	5.6	35.2	60.0
333	Machinery	58.6	47.9	7.4	**40.4**	**63.4**
334	Computer and Electronics	47.1	**59.5**	**20.4**	**48.6**	60.4
335	Electrical Equipment	**60.5**	**55.4**	9.7	28.8	62.5
336	Transportation Equipment	50.4	45.5	8.3	41.9	62.8
337	Furniture	55.2	49.2	10.8	**40.8**	57.6
339	Miscellaneous Manufacturing	56.7	**57.0**	8.7	28.9	55.4
	Total Manufacturing	59.3	53.0	11.4	39.2	63.1

Notes: *A statement is strongly agreed to when a firm scores 4 or 5 on the statement.
**Above-average numbers are in boldface.
Source: The linked SI.

Government Supports

In this paper, we control for the effects of different types of government innovation support programs on innovation activities. Government support programs are expected to play an important role in a firm's decision on whether or not to undertake an innovation activity.

For instance, Technology Partnerships Canada is a technology investment fund. It was established by the Canadian federal government to encourage private sector investment and maintain and increase the technology base and capabilities of Canadian industry, mainly by investing strategically in innovation and R&D. Similarly, the Industrial Research Assistance Program (IRAP) is a service of Canada's National Research Council. For more than 50 years, IRAP has helped Canadian firms create and adopt innovative technologies. It offers direct technical assistance to the latest technological advances, expertise, facilities and resources, as well as cost-share financing of innovative technical projects.

The six government innovation support programs in the survey are[15]

1. *R&D tax credits*;
2. *R&D grants*;
3. *venture capital support*;
4. *technology support*;
5. *information services*; and
6. *support for training*.

All these indicators are binary ordinal variables. For instance, if a firm indicated that it used R&D tax credit programs, either from the federal government or a provincial government, during the 1997-99 period, then the R&D tax credit indicator equals one; otherwise, it equals zero. The same applies to the other government support programs.

The variables represent six different types of government innovation support programs. They are not correlated with one another, except for a slight correlation between R&D tax credits and R&D grants (Table 5). Presumably, they are designed and put in place to help firms innovate. They are thus expected to have some positive impact on a firm's innovation activities. In other words, they should be partly responsible for a firm's decision to undertake innovation activities. One can argue, however, given the same time period for both the dependent and independent variables, that it is difficult to assume a causal relationship between the use of each government program and technology invention or technology adoption. One can argue particularly that the fact that the coefficient for R&D tax credits is statistically significant probably tells us very little, as firms must perform R&D to be eligible for the credits. There is no way to prove or disprove this assertion. But, we verify whether or not the absence of these variables affects the results from the effect of the competition variables on innovation activities. As we discuss in the next section, the answer is no.

Table 5
Correlation Coefficients between Government Innovation Support Programs

Government Support Programs	R&D Tax Credits	R&D Grants	Venture Capital	Technology Support	Information Services	Support for Training
R&D Tax Credits	1.00					
R&D Grants	0.34	1.00				
Venture Capital Support	0.09	0.15	1.00			
Technology Support	0.17	0.25	0.15	1.00		
Information Services	0.12	0.11	0.08	0.16	1.00	
Support for Training	0.14	0.13	0.11	0.21	0.18	1.00

Source: The linked SI.

The most popular government innovation support program is R&D tax credits, followed by government support for training (Table 6). Firms in the computer and electronics, machinery and chemical industries are leading in the use of R&D tax credits. Firms in the computer and electronics, plastics and rubber, and chemical industries are leading in the use of R&D grants. Firms in the computer and electronics, textile mills and wood industries are leading in the use of government venture capital support. Firms in computer and electronics, electrical equipment and food industries are leading in the use of government technology support and assistance programs. Firms in the petroleum and coal, chemical, and transportation equipment industries are leading in the use of government information or Internet services. Finally, firms in the beverage and tobacco, transportation equipment and electrical equipment

industries are leading in the use of government support for training. Clearly, the biggest winner of government R&D incentive programs is the computer and electronics industry, followed by the chemical industry.

Table 6
Percentage of Firms Using Government Support Programs*
(Weighted by Population)

NAICS	Industry Name	R&D Tax Credits	R&D Grants	Venture Capital	Technology Support	Internet Services	Support for Training
311	Food	**35.6**	**13.7**	2.8	**11.8**	**16.2**	**22.0**
312	Beverage and Tobacco	22.0	2.3	**3.6**	2.5	**12.6**	**27.7**
313	Textile Mills	**48.3**	6.8	**6.3**	5.6	8.4	18.0
314	Textile Product	**42.5**	6.1	2.3	**8.9**	**12.5**	**18.5**
315	Apparel	13.0	3.8	2.3	7.3	7.9	16.6
316	Leather	29.2	1.3	**3.7**	5.2	6.1	17.3
321	Wood	23.3	9.5	**5.9**	**8.8**	7.6	**20.8**
322	Paper	**35.6**	7.4	**3.5**	8.1	**10.9**	**24.3**
323	Printing	10.3	1.5	2.1	2.7	8.4	13.7
324	Petroleum and Coal	**54.6**	7.4	**5.6**	7.4	**27.8**	7.4
325	Chemical	**55.7**	**13.9**	0.9	**8.7**	**16.9**	17.8
326	Plastics and Rubber	**40.8**	**14.1**	2.1	9.2	9.9	20.3
327	Non-metallic Mineral	23.3	7.2	0.8	2.4	9.4	13.5
331	Primary Metal	**37.3**	8.4	0.5	**8.3**	**14.9**	**24.2**
332	Fabricated Metal	27.5	8.5	1.6	6.2	6.6	19.7
333	Machinery	**55.9**	**13.0**	2.5	**10.8**	**11.0**	**24.9**
334	Computer and Electronics	**65.9**	**25.0**	**7.6**	**16.3**	**11.8**	**25.7**
335	Electrical Equipment	**52.9**	**13.6**	**3.6**	**13.0**	**12.2**	**26.9**
336	Transportation Equipment	**44.2**	**10.5**	2.3	**11.1**	**16.9**	**27.1**
337	Furniture	22.2	6.4	1.5	5.7	5.7	20.4
339	Miscellaneous Manufacturing	26.8	**10.6**	**4.2**	4.4	**14.9**	20.0
	Total	34.4	9.9	2.8	8.1	10.8	20.6

Note: *Above-average numbers are in boldface.
Source: The linked SI.

3. EMPIRICAL ANALYSIS

With data from the SI, we now can study empirically the effect of different types of competition on innovation activities associated with technology invention or technology adoption. First, we set up a regression model and then discuss the empirical results under different sample restrictions.

Regression Model

As discussed earlier, innovation activities, such as technology invention (indicated by patent applications) and technology adoption (indicated by acquisition of technologies), are binary variables. A firm is a technology inventor if it makes at least one patent application. Similarly, a firm is a technology adopter if it acquires at least one technology. Given the qualitative nature of these variables, one can study the effects of different types of competition on innovation activities by examining the significance of these variables in influencing the probability of a firm becoming an inventor or adopter. Thus, we set up a logit model as follows:[16]

$$(1) \qquad \text{Prob}[y_{i,j}=1]=\left[1+\exp(-\mathbf{X}_j\boldsymbol{\beta})\right]^{-1}, \text{ and}$$

$$(2) \qquad \mathbf{X}_j\boldsymbol{\beta} = \beta_0+\beta_1 SB_j+\beta_2 CP_j+\beta_3 QO_j+\beta_4 PT_j+\beta_5 OT_j + \beta_6 SM_j+\beta_7 SL_j+\sum_{k=1}^{6}\beta_{k+7}G_{kj}+\sum_{n=1}^{20}\beta_{n+13}I_{nj}+\varepsilon_j,$$

where y_k denotes technology invention or technology adoption and is equal to one when a firm is a technology inventor or technology adopter but otherwise is equal to zero;

SB, *CP*, *QO*, *PT* and *OT* denote *easy substitution of products*, *constant arrival of competing products*, *quick obsolescence of products*, *rapid change of production technologies and rapid change of office technologies*, respectively;

SM and *SL* are dummies for medium-sized and large-sized firms;

G_k is the kth government support program;

I_n is the dummy for industry n; and

ε is the error term.

In the regression model, we control for differences in firm size and industry characteristics. Firm size and industry dummies are introduced to capture differences in technological and financial opportunities across different sizes of firms and across different industries, which are not captured by other variables. To capture the size effect, we divide firms into three groups of different sizes. Small-sized firms, which is the reference group in the regression, consist of firms with no more than 100 employees. Medium-sized firms are those with between 100 and 500 employees. Large-sized firms are those with more than 500 employees. Industry dummies are at the 3-digit NAICS level. The reference industry is apparel (NAICS 315), as firms in this industry tend to be low technology inventors and adopters, as shown in Table 2.

Empirical Results

The model in the last section is estimated under different sample restrictions for both patent applications and acquisition of technologies. The regression exercise is to identify which competition variables are significant factors influencing the probability of a firm becoming a technology inventor or adopter. First, we regress the model through the use of the whole sample. For example, the estimation for patent applications is the group of firms with patent applications against all other firms; for acquisition of technologies, it is the group of firms with acquisition of technologies against all other firms. The estimation results for patent applications and acquisition of technologies are reported in Table 7.[17] However, the design of the regressions is problematic, as it uses firms with patent applications against firms with acquisition of technologies, or vice versa. For the regression of patent applications in Table 7, these "patent applicators" are grouped against "others." This means that some firms in the other group are "technology adopters." This certainly underestimates the effects of independent variables that have the same signs for both patent applications and acquisition of technologies, and overestimates the effects of independent variables that have the opposite signs for patent applications and acquisition of technologies. For instance, if *constant arrival of competing products* has a positive effect for both patent applications and acquisition of technologies, then when firms with patent applications are regressed against firms with acquisition of technologies, the regression will underestimate the effect of this variable on the probability of firms becoming a patent applicator.

To minimize this problem, we restrict the sample in the regression analysis. For patent applications, we select only firms with patent applications or without any innovation activity. In this paper, a firm is considered to be without innovation activity if it has a value of zero in any of the six indicators: patent applications, acquisition of technologies, trademarks, copyrights, R&D and industrial design.[18] The design is to use patent applicators against firms without innovation activity and to estimate the effect of the independent variables on the probability that a firm will become a patent applicator. Similarly, for the regression for acquisition of technologies, we select only firms with acquisition of technologies or without innovation activity.[19] As expected, the new estimates of the coefficients on most independent variables in Table 8 (under the restricted samples) are significantly different from those in Table 7 (under no sample restriction). For instance, the estimate of the coefficient on *constant arrival of competing products* becomes more significant when the sample is restricted, especially for patent applications. Similarly, *rapid change of production technologies* and *rapid change of office technologies* are more significant, especially for acquisition of technologies. In the new regressions, the effect of *rapid change of production technologies* on patent applications becomes positive and significant, as compared to negative and significant.

The new results show that *easy substitution of products* is negative and highly significant for patent applications and marginally significant for acquisition of technologies. This result is consistent with the observation by Kamien and Schwartz that innovation is often designed to reduce uncertainty or mitigate its consequences, and ultimately is motivated by the anticipation of "monopoly power" or market dominance and the concomitant extraordinary future profits. When a firm perceives that its clients can substitute its products for the products of its competitors easily, the future profit of an innovation becomes uncertain, which translates into a low level of expected returns. Consequently, this reduces the incentive for the firm to undertake innovation activities.

Table 7
Logit Estimation Results for Patent Applications or Acquisition of Technologies (Whole Sample)

Variable	Patent Applications		Acquisition of Technologies	
	Estimate	t-statistic	Estimate	t-statistic
Easy Substitution of Products	-0.059	-2.44*	-0.042	-2.03*
Constant Arrival of Competing Products	0.087	3.62*	0.052	2.62*
Quick Obsolescencee of Products	0.039	1.45	-0.048	-2.09*
Rapid Change of Production Technologies	-0.074	-2.63*	0.361	15.20*
Rapid Change of Office Technologies	0.034	1.18	0.026	1.12
R&D Tax Credits	0.947	14.50*	0.823	12.43*
Government R&D Grants	0.517	5.71*	0.395	3.39*
Venture Capital Support	0.039	0.23	0.491	2.40*
Technology Support	-0.142	-1.31	0.123	1.07
Internet Services	0.294	3.31*	0.113	1.22
Support for Training	-0.190	-2.54*	0.372	5.18*
Medium-sized Firms	0.868	13.42*	0.546	8.93*
Large-sized Firms	1.453	12.25*	0.764	5.30*
Food	0.694	2.42*	0.176	1.34
Beverage and Tobacco	1.749	4.62*	-0.092	-0.36
Textile Mills	1.154	3.29*	0.225	1.01
Textile Product	1.985	5.89*	0.519	2.11*
Leather	1.561	3.77*	-0.047	-0.16
Wood	0.466	1.51	0.178	1.32
Paper	1.384	4.53*	0.246	1.37
Printing	1.427	4.79*	0.790	5.07*
Petroleum and Coal	1.626	3.76*	-0.198	-0.60
Chemical	2.067	7.38*	-0.085	-0.57
Plastics and Rubber	2.265	8.21*	0.378	2.53*
Non-metallic Mineral	1.999	6.79*	-0.389	-2.58*
Primary Metal	1.273	3.90*	0.394	1.94**
Fabricated Metal	1.964	7.28*	0.115	0.96
Machinery	2.674	9.95*	0.008	-0.06
Computer and Electronics	2.418	8.41*	-0.043	-0.23
Electrical Equipment	2.585	8.69*	0.084	-0.44
Transportation Equipment	1.780	6.29*	-0.117	-0.77
Furniture	2.040	7.17*	0.412	2.76*
Miscellaneous Manufacturing	2.408	8.47*	0.342	2.20*
Constant	-4.212	-14.20*	-0.751	-4.95*
Number of Observations	5,451		5,451	

Note: * and ** denote significance at 5 and 10 percent, respectively.

Table 8
Logit Estimation Results for Patent Applications or Acquisition of Technologies (Restricted Sample)[a]

Variable	Patent Applications		Acquisition of Technologies	
	Estimate	t-statistic	Estimate	t-statistic
Easy Substitution of Products	-0.135	-3.09*	-0.057	-1.98*
Constant Arrival of Competing Products	0.153	3.64*	0.075	2.73*
Quick Obsolescence of Products	0.093	1.84**	0.011	0.33
Rapid Change of Production Technologies	0.295	5.75*	0.434	12.96*
Rapid Change of Office Technologies	0.096	1.95**	0.078	2.49*
R&D Tax Credits	2.503	16.50*	1.784	13.41*
Government R&D Grants	1.768	4.91*	1.390	4.26*
Venture Capital Support	-0.127	-0.24	0.538	1.59
Technology Support	0.476	1.31	0.961	3.56*
Internet Services	0.480	2.32*	0.357	2.30*
Support for Training	0.383	2.42*	0.524	4.65*
Medium-sized Firms	1.362	10.92*	0.744	8.08*
Large-sized Firms	2.040	7.37*	0.791	3.52*
Food	0.723	1.84**	-0.094	-0.51
Beverage and Tobacco	1.737	3.03*	-0.087	-0.24
Textile Mills	0.777	1.46	-0.425	-1.49
Textile Product	2.725	4.68*	0.791	1.81**
Leather	1.166	1.64	0.206	0.46
Wood	0.236	0.57	-0.244	-1.36
Paper	2.144	4.75*	0.271	1.04
Printing	1.356	3.42*	0.357	1.76**
Petroleum and Coal	1.037	1.48	-0.474	-1.04
Chemical	2.298	5.60*	0.226	0.95
Plastics and Rubber	2.376	6.08*	0.344	1.57
Non-metallic Mineral	1.357	3.43*	-0.680	-3.41*
Primary Metal	1.211	2.47*	0.040	0.15
Fabricated Metal	1.703	4.73*	0.006	0.04
Machinery	2.815	7.43*	0.371	1.78**
Computer and Electronics	2.458	4.93*	0.649	1.79**
Electrical Equipment	2.055	4.62*	-0.242	-0.86
Transportation Equipment	1.132	2.84*	-0.499	-2.42*
Furniture	2.434	6.24*	0.309	1.49
Miscellaneous Manufacturing	2.494	6.29*	0.121	0.57
Constant	-4.048	-9.78*	-0.566	-2.78*
Number of Observations	1,705		4,661	

Notes: * and ** denote significance at 5 and 10 percent, respectively.
[a]For the patent application regression, the restricted sample includes firms with patent applications or without any innovation activities, as indicated by the six innovation indicators; for acquisition of technologies, it includes firms with acquisition of technologies or without any innovation activity.

All other competition variables are positive for patent applicat ·s, acquisition of technologies or both. *Constant arrival of competing products* has a positive and signif effect on these two indicators. The fact that the estimated coefficient on this variable is much larger fo, patent applications than for acquisition of technologies implies that the factor is more important for technology invention than for technology adoption. This result may be due to the fact that technology invention has more to do with introducing or improving products than improving production processes. *Quick obsolescence of products* is marginally significant only for patent applications. *Rapid change of production technologies* is significant for both patent applications and acquisition of technologies. The estimated coefficient on this variable is much larger and more significant for acquisition of technologies than for patent applications, implying that the variable is more important for driving technology adoption than for motivating technology invention. This result may be due to the fact that technology adoption has more to do with improving production processes than introducing or improving products. *Rapid change of office technologies* is also positive for both patent applications and acquisition of technologies, and significant for acquisition of technologies but only marginally significant for patent applications.

For government innovation support programs, R&D tax credits and R&D grants are highly significant and more important for patent applications than for acquisition of technologies. Venture capital support is not significant for either patent applications or acquisition of technologies. Technology support is only significant for acquisition of technologies. Finally, Internet services and support for training are significant for both patent applications and acquisition of technologies.

After controlling for other factors, we find that larger-sized firms are more likely to become patent applicators or technology adopters than smaller-sized firms. At the industry level, firms in the machinery, textile product and computer and electronics industries are most likely to be patent applicators, while firms in the apparel and wood industries are the least likely to be patent applicators. Similarly, firms in the textile product, computer and electronics, and machinery industries are most likely to be technology adopters, while firms in the non-metallic mineral, transportation equipment, and petroleum and coal industries are least likely to be technology adopters. The finding that textile mills is among the industries whose firms are most likely to be patent applicators and technology adopters is surprising and interesting, but it is consistent with the evidence in Table 2, which shows that this industry is above average in terms of the percentage of firms with patent applications, acquisition of technologies or R&D. It is also consistent with the evidence of Baldwin and Da Pont (1993). They show that textiles is one of the most innovative industries, investing heavily in machinery and equipment and adopting advanced technologies.

One may argue that the patent application variable is only a partial indicator for technology invention, as not all inventions are patented. Sometimes it is desirable for some firms to use trademarks or copyrights to protect their intellectual property. As discussed earlier, patents are used often by firms in the machinery, computer and electronics, and electrical equipment industries. However, trademarks are used often by firms in the beverage and tobacco, textile product and chemical industries, and copyrights by firms in the computer and electronics and beverage and tobacco industries. Thus we also estimate the model for trademarks and copyrights to supplement the regression for patent applications. To estimate the effect of competition variables on trademarks and copyrights, we again restrict the sample. For trademarks, we select only firms with trademarks but no patent applications, or firms without any innovation activity. We exclude firms with patent applications from the group of firms with trademarks, as patents are generally more technological than trademarks. Similarly, for copyrights, we select only firms with copyrights but no patent applications, or firms without any innovation activity. The estimation

results for both trademarks and copyrights (Table 9) are very similar to those for patent applications (Table 8), except that *quick obsolescence of products* and technology support become more significant than before.

In addition, one can argue that there is a causality problem here, especially for patent applications. Both the dependent and the independent variables refer to the same time period, 1997-99. It is therefore difficult to assume a causal relationship between competition variables and patent applications, as a patent application in the period may be due to innovation activities undertaken in previous periods. In other words, innovation activities within a period of time may not lead to a patent application or a complete project for technology adoption. This is possible, as the survey shows that during the 1997-99 period, 50 percent of the firms had unsuccessful or not yet completed projects. But, one can also argue that the competition environment does not change dramatically from one period to another, which means that firms may have faced similar competition during earlier periods. If this is the case, the regression results are still valid, even when patent applications are associated with innovation activities undertaken in previous periods. Nonetheless, we also examine the effects of the competition variables on two intermediaries of technology invention and technology adoption: R&D and industrial design supplement the analyses for patent applications and acquisition of technologies. We include industrial design mainly because of its close association with R&D (Table 1). The disadvantage of the exercise is that we cannot untangle the effects of the competition variables on technology invention from their effects on technology adoption, as R&D and industrial design are intermediaries to both technology invention and technology adoption. For R&D, we select only firms with R&D or no innovation activity. Similarly, for industrial design, we select only firms with industrial design or no innovation activity. Basically, the estimation results in Table 10 are consistent with previous results (Table 8).

Furthermore, as discussed previously, the results for the significance of government support programs should be interpreted with caution. These programs are designed and put in place to help firms innovate, and they are expected to have a positive influence on a firm's decision to undertake innovation. One may argue, however, given the same time period for both the dependent and independent variables, that it is difficult to assume a causal relationship between the use of each government program and technology invention or technology adoption. Particularly, one may argue that the fact that the coefficient for R&D tax credits is statistically significant probably tells us very little, as firms must perform R&D to be eligible for the credits. There is no way to prove or disprove this assertion. The analysis so far has worked under the assumption that these government programs have an impact on a firm's decision to undertake innovation activities. Now, we assume that they do not have an impact. We exclude the six variables representing the government support programs from the model and rerun the estimation done for Table 8. The same conclusions are obtained from the new regression (Table 11). Thus, the presence or absence of the six government variables has no impact on our conclusions concerning the other independent variables.

Table 9
Logit Estimation Results for Trademark or Copyright
(Restricted Sample)[a]

Variable	Trademark		Copyright	
	Estimate	t-statistic	Estimate	t-statistic
Easy Substitution of Products	-0.028	-0.79	-0.168	-3.50*
Constant Arrival of Competing Products	0.142	4.22*	0.127	2.74*
Quick Obsolescence of Products	0.091	2.33*	0.176	3.31*
Rapid Change of Production Technologies	0.286	6.98*	0.180	3.16*
Rapid Change of Office Technologies	0.088	2.30*	0.135	2.51*
R&D Tax Credits	1.605	11.11*	1.318	7.02*
Government R&D Grants	1.531	4.36*	1.170	2.85*
Venture Capital Support	0.244	0.61	0.223	0.42
Technology Support	1.170	3.96*	0.483	1.28
Internet Services	0.459	2.65*	0.607	2.89*
Support for Training	0.650	4.95*	0.614	3.45*
Medium-sized Firms	0.836	7.75*	1.139	8.03*
Large-sized Firms	0.740	2.89*	1.359	4.27*
Food	-0.428	-2.19*	0.463	1.47
Beverage and Tobacco	-0.152	-0.41	1.438	3.01*
Textile Mills	-1.310	-3.76*	0.169	0.36
Textile Product	0.776	1.69**	1.882	3.28*
Leather	0.208	0.44	0.165	0.20
Wood	-1.582	-7.35*	-1.195	-2.84*
Paper	-0.754	-2.38*	-0.036	-0.07
Printing	-1.130	-4.73*	1.177	3.64*
Petroleum and Coal	-1.368	-2.51*	-0.859	-0.95
Chemical	-0.254	-0.99	0.876	2.34*
Plastics and Rubber	-0.384	-1.59	0.638	1.76**
Non-metallic Mineral	-1.309	-5.59*	-0.055	-0.15
Primary Metal	-1.508	-4.20*	0.045	0.09
Fabricated Metal	-0.970	-5.18*	0.467	1.54
Machinery	-0.488	-2.10*	0.946	2.74*
Computer and Electronics	-0.079	-0.20	1.914	4.14*
Electrical Equipment	-1.360	-3.88*	0.779	1.72**
Transportation Equipment	-1.686	-6.66*	0.259	0.74
Furniture	-0.442	-1.89**	0.563	1.48
Miscellaneous Manufacturing	-0.354	-1.49	1.483	4.36*
Constant	-1.045	-4.35*	-3.048	-7.97*
Number of Observations	1,984		999	

Notes: * and ** denote significance at 5 and 10 percent, respectively.
[a]For the trademark regression, the sample includes firms with trademarks but no patent applications or firms without any innovation activities, indicated by the six innovation indicators; for the copyright regression, it includes firms with copyrights but no patent applications or firms without any innovation activity.

Table 10
Logit Estimation Results for R&D or Industrial Design
(Restricted Sample)[a]

Variable	R&D		Industrial Design	
	Estimate	t-statistic	Estimate	t-statistic
Easy Substitution of Products	-0.095	-3.14*	-0.115	-3.74*
Constant Arrival of Competing Products	0.127	4.41*	0.136	4.59*
Quick Obsolescence of Products	0.076	2.28*	0.044	1.24
Rapid Change of Production Technologies	0.381	10.94*	0.382	10.70*
Rapid Change of Office Technologies	0.105	3.17*	0.107	3.13*
R&D Tax Credits	2.110	15.90*	2.002	14.92*
Government R&D Grants	1.605	4.93*	1.510	4.58*
Venture Capital Support	0.702	1.98*	0.450	1.27
Technology Support	1.107	4.02*	1.064	3.86*
Internet Services	0.235	1.47*	0.399	2.47*
Support for Training	0.474	4.06*	0.532	4.52*
Medium-sized Firms	0.837	8.84*	0.962	10.02*
Large-sized Firms	0.913	4.00*	1.101	4.80*
Food	-0.007	-0.03	0.264	1.30
Beverage and Tobacco	0.281	0.76	0.486	1.25
Textile Mills	-0.143	-0.48	0.333	1.06
Textile Product	0.823	1.85**	0.652	1.39
Leather	0.543	1.22	0.471	0.97
Wood	-0.405	-2.10*	0.183	0.91
Paper	0.247	0.89	0.787	2.79*
Printing	0.156	0.72	0.282	1.23
Petroleum and Coal	-0.398	-0.84	-0.045	-0.09
Chemical	0.507	2.08*	0.771	3.00*
Plastics and Rubber	0.643	2.84*	1.014	4.33*
Non-metallic Mineral	-0.341	-1.64	-0.156	-0.70
Primary Metal	0.188	0.68	0.817	2.89*
Fabricated Metal	0.060	0.34	0.575	3.09*
Machinery	0.578	2.68*	1.167	5.22*
Computer and Electronics	0.795	2.15*	1.199	3.17*
Electrical Equipment	0.072	0.25	0.554	1.90**
Transportation Equipment	-0.325	-1.50	0.146	0.65
Furniture	0.423	1.94**	0.871	3.82*
Miscellaneous Manufacturing	0.406	1.81**	0.746	3.18*
Constant	-1.088	-4.99*	-1.572	-6.69*
Number of Observations	4,279		3,726	

Notes: * and ** denote significance at 5 and 10 percent, respectively.
[a] For the R&D regression, the sample includes firms with R&D or without any innovation activities, indicated by the six innovation indicators; for industrial design, it includes firms with industrial design or without any innovation activity.

Table 11
Logit Estimation Results for Patent Applications or Acquisition of Technologies (Restricted Sample)[a]

Variable	Patent Applications		Acquisition of Technologies	
	Estimate	t-statistic	Estimate	t-statistic
Easy Substitution of Products	-0.179	-4.66*	-0.109	-3.86*
Constant Arrival of Competing Products	0.212	5.77*	0.115	4.35*
Quick Obsolescence of Products	0.109	2.44*	0.041	1.28
Rapid Change of Production Technologies	0.319	7.08*	0.458	14.27*
Rapid Change of Office Technologies	0.084	1.96**	0.098	3.26**
Medium-sized Firms	1.434	12.89*	0.872	9.74*
Large-sized Firms	2.231	9.13*	1.178	5.42*
Food	1.207	3.52*	0.315	1.78**
Beverage and Tobacco	1.658	3.24*	0.017	0.05
Textile Mills	1.016	2.28*	0.027	0.10
Textile Product	3.059	5.77*	1.223	2.88*
Leather	1.345	2.20*	0.340	0.79
Wood	0.464	1.28	-0.049	-0.28
Paper	2.189	5.45*	0.518	2.04*
Printing	1.161	3.23*	0.317	1.58
Petroleum and Coal	1.953	3.38*	0.184	0.43
Chemical	2.885	8.02*	0.795	3.49*
Plastics and Rubber	2.791	8.02*	0.696	3.27*
Non-metallic Mineral	1.491	4.27*	-0.488	-2.53*
Primary Metal	1.527	3.64*	0.329	1.28
Fabricated Metal	2.147	6.75*	0.258	1.59
Machinery	3.522	10.52*	1.041	5.21*
Computer and Electronics	3.723	8.25*	1.451	4.10*
Electrical Equipment	2.662	6.85*	0.311	1.17
Transportation Equipment	1.758	5.10*	-0.099	0.50
Furniture	2.375	6.77*	0.484	2.37*
Miscellaneous Manufacturing	2.623	7.50*	0.382	1.85**
Constant	-3.652	-10.05*	-0.505	-2.53*
Number of Observations	1,705		4,661	

Notes: * and ** denote significance at 5 and 10 percent, respectively.
[a] For the patent application regression, the restricted sample includes firms with patent applications or without any innovation activities, as indicated by the six innovation indicators; for acquisition of technologies, it includes firms with acquisition of technologies or without any innovation activity.

Finally, we verify the impact of a firm's market shares, either in gross output or value-added, on its innovation activities. The market share of a firm in terms of gross output (value-added) is defined as a firm's gross output or value-added divided by the gross output or value-added of its industry at the 3-digit NAICS level, as shown in Table 2.[20] The regression results show that market share based on gross output or value-added has no significant impact on patent applications or acquisition of technologies, with or without the presence of other competition variables (results are not reported). We also verify complementarities among competition variables. They are complementary if they act together, reinforce each other and increase the probability of a firm becoming a technology inventor or technology adopter (for a formal discussion and testing, see Mohnen and Röller, 2001). Empirically, this means that the coefficient on an extra dummy for a group of competition variables taking place simultaneously will be statistically significant. However, there was no empirical evidence for the existence of such complementarities among the five types of competition (results are not reported). This is consistent with the relatively small correlation coefficients among these variables, as shown in Table 3. Similarly, we verify complementarities among the government innovation support programs. Again, we find no evidence of complementarities among these programs. This result is also consistent with the relatively small correlation coefficients among these variables (Table 5).

4. CONCLUSION

In this paper, we analyse innovation activities of Canadian manufacturing firms and hypothesize that different types of competition have different impacts on two types of innovation activities: technology invention and technology adoption. We examine five types of competition perceptions: *easy substitution of products*, *constant arrival of competing products*, *quick obsolescence of products*, *rapid change of production technologies*, and *rapid change of office technologies*. We find that not all types of competition perceptions promote innovation activities and that some competition perceptions are an impediment to innovation activities. The econometric results show that

- *easy substitution of products* is an impediment to innovation activities, especially for technology invention;
- *constant arrival of competing products* is a driving force behind innovation activities, especially for technology invention;
- *quick obsolescence of products* is only marginally significant and positive for technology invention;
- *rapid change of production technologies* is a driving force behind innovation activities, especially for technology adoption; and
- *rapid change of office technologies* has a significant and positive effect on technology adoption but is only marginally significant and positive for technology invention.

In addition, we find that R&D tax credits and R&D grants are the most significant government innovation programs, although the other programs, except for venture capital support, are also important for technology invention, technology adoption or both. Finally, large-sized firms are more likely than small-sized firms to undertake both technology invention and technology adoption.

However, these results should be interpreted with three caveats. First, patent application within a period of time may not necessarily reflect invention activities during that period. This is not a problem if the competition environment does not change quickly from one period to another. Given that firms can undertake technology invention with or without competition, the consistent empirical results on the effect of the competition variables on patent applications indicate that there is a causality between patent applications and the types of competition specified above. Second, the data on variables from the SI are qualitative in nature. For instance, acquisition of technologies is a binary variable. It is equal to one for firms that acquired technologies regardless of intensity, and zero for others. Because of their size, large-sized firms are more likely to become technology inventors or technology adopters than small-sized firms. One can argue that this is also true in terms of competition and the use of government support programs, as large-sized firms are more diversified in products and processes than small-sized firms. The size effects on innovation activities, however, can be different from those on competition perceptions or government support programs. Thus the empirical result that large-sized firms are more likely to be technology inventors or technology adopters should be interpreted with caution, although it is in line with the findings of Baldwin and Sabourin (1996) and consistent with the Schumpeter hypothesis — large firms are proportionately more innovative than small firms (Kamien and Schwartz). Finally, the survey data used for the analysis in this paper are a cross-section sample, which only allows one to build a link between competition and innovation activities by capturing the pattern of variation across firms. This sample may be adequate for estimating the effects of competition on innovation activities, because whether or not they face competition, firms have a choice in undertaking any innovation activity. It may not be adequate for assessing the effectiveness of R&D tax credits on innovation activities, because firms

must engage in R&D activities to be eligible for R&D tax credits. In this case, a time-series sample is required.

Notwithstanding these caveats, the evidence presented in this paper highlights the importance of different types of competition perceptions for different types of innovation activities. It shows that competition is generally desirable for innovation, but that *easy substitution of products* is an impediment to innovation. These findings may have important implications for the decision by a country to promote innovation activities by means of competition measures. For instance, they support a country's efforts to make its intellectual property system more effective by preventing or reducing imitation of an innovation product. They also clearly support government initiatives such as those under the IRAP in Canada. Perceptions of *rapid change of production technologies* are a driving force behind technology adoption. Thus, a country can promote investment in technologies by exposing firms to current available technologies. Such initiatives are simple and basic, but they are important for creating an environment where firms feel the pressure to innovate.

NOTES

1 For instance, JDS Uniphase Corp. and Texas Instruments Inc. are both classified as semiconductor and related device manufacturing. Their primary SIC (Standard Industrial Classification) is 3674 and their primary NAICS (North American Industry Classification System) is 334413. However, they are not competing against each other. JDS Uniphase Corp. designs, develops, manufactures and distributes fibre optic components, modules and subsystems for the fibre optic communications industry. Texas Instruments develops, manufactures and sells semiconductors (such as digital signal processors, analog integrated circuits and computing microprocessors), sensors and controls (such as electrical and electronic controls, sensors and ratio frequency identification systems) and educational and productivity solutions (such as graphing and educational calculators) for both industrial and consumer markets.

2 In 1999, the export-sales ratio for the Canadian manufacturing sector was 57 percent.

3 Presumably, in a country with no intellectual property protection system, or an ineffective one, cheaper and unauthorized copies of an innovation product can flood the market quickly and make it impossible for its inventor to recover the costs of the invention, which provides no incentive for a firm to invent.

4 Technological innovation activities are different from organizational innovation activities. The former are associated mainly with activities linked to offering new or significantly improved products or production processes, while the latter are associated mainly with human resource management and managerial practices.

5 Under this definition, an invention or a patent application can only be considered as an innovation activity, since it may not yet have gone into commercial production.

6 Technology invention is often called fundamental innovation, and technology adoption is called applied innovation (Rao, Ahmad, Horsman and Kaptein-Russell, 2001).

7 For a discussion on methodology and an overall description of the survey, see Schaan and Anderson (2001).

8 The criterion of "more than 19 employees," which is based on employment information in 1999, is used to design the sample. For some reason, the linked data base contains only employment data based on the 1997 ASM.

9 Patent applications is based on question 26 in the survey: "Did your firm apply for at least one patent during the last three years, 1997 to 1999?" Acquisition of technologies, R&D and industrial design are based on question 6: "During the last three years, 1997 to 1999, did your firm engage in the following activities, which are linked to offering new or significantly improved products, or to introducing new or significantly improved production/manufacturing processes?" Acquisition of technologies stands for acquisition of machinery, equipment or other technology, and industrial design stands for industrial engineering and industrial design. Trademarks and copyrights are based on question 25: "Please indicate which of the following methods have been used by your firm to protect its intellectual property during the past three years, 1997 to 1999."

10 We use question 26 instead of question 25 (whether a firm used patents to protect its intellectual property during the past three years, 1997 to 1999) because the former is most likely closer to current invention activities than the latter. However, similar results are produced when question 25 is used.

11 On the issue of R&D, question 6 is very similar to question 24, which asks whether a firm undertook R&D activities during the 1997-99 period. They both produce similar results.

12 For some reason, R&D is only slightly correlated with patent applications. This may reflect the fact that current R&D is not necessarily associated with current patent applications.

13 These variables are based on survey question 1 on the competitive environment: "For your firm, how strongly do you agree or disagree with each of the following statements? Please indicate your opinion by using the following scale, where 1 is strongly disagree and 5 is strongly agree. Check 0 if not relevant to your firm." *Easy substitution of products* stands for the statement: "My clients can easily substitute my products for the products of my competitors." *Constant arrival of competing products* stands for the statement: "The arrival of competing products is a constant threat." *Quick obsolescence of products* stands for the statement: "My products quickly become obsolete." *Rapid change of production technologies* stands for the statement: "Production technologies change rapidly." *Rapid change of office technologies* stands for the statement: "Office technologies change rapidly."

14 At the beginning of the study, we also tried to include the statement: "The arrival of new competitors is a constant threat." For some reason, it is insignificant, with or without the presence of other competition statements and has no impact on the estimation results of other variables. It is therefore excluded from the final analysis.

15 These variables are based on survey question 29 on government support programs: "Has your firm used any of the following types of programs sponsored by the federal government or a provincial government during the last three years, 1997 to 1999?" *R&D tax credits* stands for "research and development tax credits." *R&D grants* stands for "government research and development grants." *Venture capital support* stands for "government venture capital support." *Technology support* stands for "government technology support and assistance programs." *Information services* stands for "government information or Internet services." *Support for training* stands for "government support for training."

16 Similar results are obtained if a probit model is used.

17 We ran two sets of regressions, weighted (by population) and unweighted. The weighted and unweighted estimation results are very similar. The reported results in Table 7 and other tables are based on weighted regressions.

18 One may not want to go so far as to exclude firms with trademarks and copyrights, as they represent low-level technological innovation. But some acquisition of technologies can also be low-level technological innovation activities. Nonetheless, the results with or without the exclusion of firms with trademarks and copyrights are very similar.

19 One could go further to exclude technology adopters from the group of patent applicators for the regression on patent applications and patent applicators from the group of technology adopters for the regression on acquisition of technologies. We argue that this may not be desirable, as technology invention and technology adoption could be complementary. For instance, technology invention is often facilitated through the use of new technologies. Nonetheless, further constraints on the sample will have no effect on the main conclusions in this paper.

20 For the regressions, one can simply use a firm's gross output or value-added (in logarithm) in place of market share, because of the presence of industry dummies and the fact that total industry gross output or value-added is the same for firms in the same industry. Note, however, that the interpretation of industry dummies is changed under the new regressions.

BIBLIOGRAPHY

Baily, Martin Neil, and Hans Gersbach."Efficiency in Manufacturing and the Need for Global Competition." *Brookings Papers on Economic Activity, Microeconomics 0*, 1995, pp. 307-47.

Baldwin, John R., and Moreno Da Pont. *Innovation in Canadian Manufacturing Enterprises*. Ottawa: Statistics Canada, Catalogue No. 88-513, 1993.

Baldwin, John R., and David Sabourin. "Technology and Competitiveness in Canadian Manufacturing Establishments." *Canadian Economic Observer*, Statistics Canada, 1996 (May).

Blundell, R., R. Griffith and J. van Reenen. "Market Share, Market Value and Innovation in a Panel of British Manufacturing Firms." *Review of Economic Studies* 66 (1999): 529-54.

Boone, Jan, and Theon Van Dijk. "Competition and Innovation." *De Economist* 146, 3 (1998): 445-61.

Carlton, Dennis W., and Jeffrey M. Perloff. *Modern Industrial Organization*. Third edition. Boston: Addison Wesley Longman, 2000.

Cohen, Wesley M., and Richard C. Levin. "Empirical Studies of Innovation and Market Structure." In *Handbook of Industrial Organization*. Edited by R. Schmalensee and R. Willig. Amsterdam: Elsevier, 1989.

Council of Economic Advisers. *Economic Report of the President*. Washington: United States Government Printing Office, 2001.

Dasgupta, Partha, and Joseph E. Stiglitz. "Industrial Structure and the Nature of Innovative Activity." *Economic Journal* 90 (1980): 266-93.

Geroski, Paul A. "Innovation, Technological Opportunity, and Market Structure." *Oxford Economic Papers* 42 (1990): 586-602.

Green, Alison, and David G. Mayes. "Technical Inefficiency in Manufacturing Industries." *Economic Journal* 101 (1991): 523-38.

Kamien, Morton I., and Nancy L. Schwartz. *Market Structure and Innovation*. Cambridge: Cambridge University Press, 1982.

Mohnen, Pierre, and Lars-Hendrick Röller. "Complementarities in Innovation Policy." Center for Interuniversity Research and Analysis on Organizations (CIRANO), Scientific Series, 2001.

Nickell, Stephen J. "Competition and Corporate Performance." *Journal of Political Economy* 104 (1996): 725-46.

Pilat, Dirk. "Competition, Productivity and Efficiency." *OECD Economic Studies 0*, 27 (1996): 107-46.

Porter, Michael. *The Competitive Advantage of Nations*. New York: Macmillan, 1990.

Rao, Someshwar, Ashfaq Ahmad, William Horsman and Phaedra Kaptein-Russell. "The Importance of Innovation for Productivity." *International Productivity Monitor* 2 (2001): 11-18.

Schaan, Susan, and Frances Anderson. *Innovation in Canadian Manufacturing: National Estimates.* Ottawa: Statistics Canada, Cat. No. 88F0006XIE01010, 2001.

Van de Klundert, Theo, and Sjak Smulders. "Growth, Competition and Welfare." *Scandinavian Journal of Economics* 99, 1 (1997): 99-118.

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No. 10 **Productivity Issues in Canada**, Someshwar Rao and Andrew Sharpe eds., University of Calgary Press, 2002.

No. 11 **North American Linkages: Opportunities and Challenges for Canada**, Richard G. Harris ed., University of Calgary Press, 2003.

JOINT PUBLICATIONS

Capital Budgeting in the Public Sector, in collaboration with the John Deutsch Institute, Jack Mintz and Ross S. Preston eds., 1994.

Infrastructure and Competitiveness, in collaboration with the John Deutsch Institute, Jack Mintz and Ross S. Preston eds., 1994.

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